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Ambient-Noise Prediction

Volume 2 - Model Evaluation with IOMEDEX Data
[Unclassified Title]

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Acoustics Division

July 1, 1974

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COMPANION REPORT

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(U) Ambient sea noise for frequencies $20 \leqslant f \leqslant 120$ Hz is due principally to shipping and should therefore be predictable from knowledge of all ships. As was reported in the first volume, a point-source model of noise in this frequency band has been developed at NRL to predict statistical as well as dynamic ambient noise levels. The model uses shipping information and transmission-loss data as inputs. This second volume reports on a test of the model using

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data taken in the Mediterranean Sea; ambient-noise values computed using the NRL model are compared with noise measurements made by five midwater hydrophones over a 12-hour period. Results of the test indicate that in areas of high shipping density the point method of computing ambient noise from known shipping and transmission loss is valid. However, it is shown that errors in the computed time series of noise arising from uncertainties in the inputs may be expected to be almost as large as fluctuations in the measured noise. Hence a statistical noise calculation, easy to implement and yielding compact results, is as useful in many applications as a rigorous dynamic calculation.

CONTENTS

AMBIENT-NOISE PREDICTION
VOLUME 2 — MODEL EVALUATION WITH IOMEDEX DATA
[Unclassified Title]

INTRODUCTION

(C) This report presents the results of a test of the NRL low-frequency ambient-noise model, discussed in the first volume (cited on the inside front cover). The test uses the results of IOMEDEX, an experiment embodying the measurement of omnidirectional ambient noise at low frequency (20 to 300 Hz), transmission loss, and the simultaneous ship survey of the Ionian Sea. The IOMEDEX ship survey together with the transmission-loss data have been used to compute time series of ambient noise levels for comparison with those measured.

(U) Ambient noise arising from a finite set of discrete sources may be computed from knowledge of the source level and transmission loss from each source to the receiver. Ship length, speed, and type of propulsion determine source levels versus frequency for merchant ships [1,2]. This information may be obtained either by survey or from archives. Transmission loss depends on the environment, the range from each source to the receiver, and the receiver depth. The transmission-loss field about a receiver can be mapped by a combination of measurement and calculation, so that if ranges are specified and the receiver depth is known, the transmission loss from each source to the receiver may be determined. Ranges can be obtained by survey or from archival shipping distributions. Thus there are three alternatives for inputs to the model: archives for shipping and environmental data (to calculate transmission loss), a survey for shipping and measurement of transmission loss, and a combination of the previous two. For this test of the NRL point-source ambient-noise model, we have chosen a ship survey and transmission-loss measurement as inputs.

(U) A demanding test of the model is the comparison between a dynamic (time varying) ambient-noise calculation and the corresponding measured time series. Accordingly, in the present model evaluation a 12-hour segment of ambient noise data taken simultaneously at five receiver depths was selected to coincide with the most comprehensive shipping survey made during Project IOMEDEX on 14 November 1971 [3] for time-series comparison of measured and predicted ambient noise. Also, this portion of data was compared to the results of a statistical noise calculation to determine the relative significance of errors in shipping data and transmission-loss data used in the calculation. Results of these model tests show that ambient noise generated primarily by surface shipping in the Mediterranean Sea can be computed for the omnidirectional case to an accuracy limited only by the accuracy of the input shipping and transmission-loss data. Extensions to other geographical areas will be discussed.

Note: Manuscript submitted April 12, 1974.

COMPUTED NOISE VERSUS MEASURED NOISE

Approach

(U) The approach to the experiment is as follows. Locations of the surface ships (sources of noise) are determined from shipping surveys and carefully catalogued to avoid duplication. Along with the locations is included information such as course, speed, length, and type of ship. The transmission-loss field to surface sources from the receiver is mapped using both measured values and values computed by Fleet Numerical Weather Central (FNWC) for each receiver depth. Transmission loss from each ship as it moves with time through the transmission-loss field may then be determined. The ambient noise level is computed as a function of time so that its time series may be compared directly with that of the measured noise. Individual ships (source points) are listed in order of decreasing importance determined by the calculation. Dominant factors about the computation are determined from this list and from the time series of the computed noise.

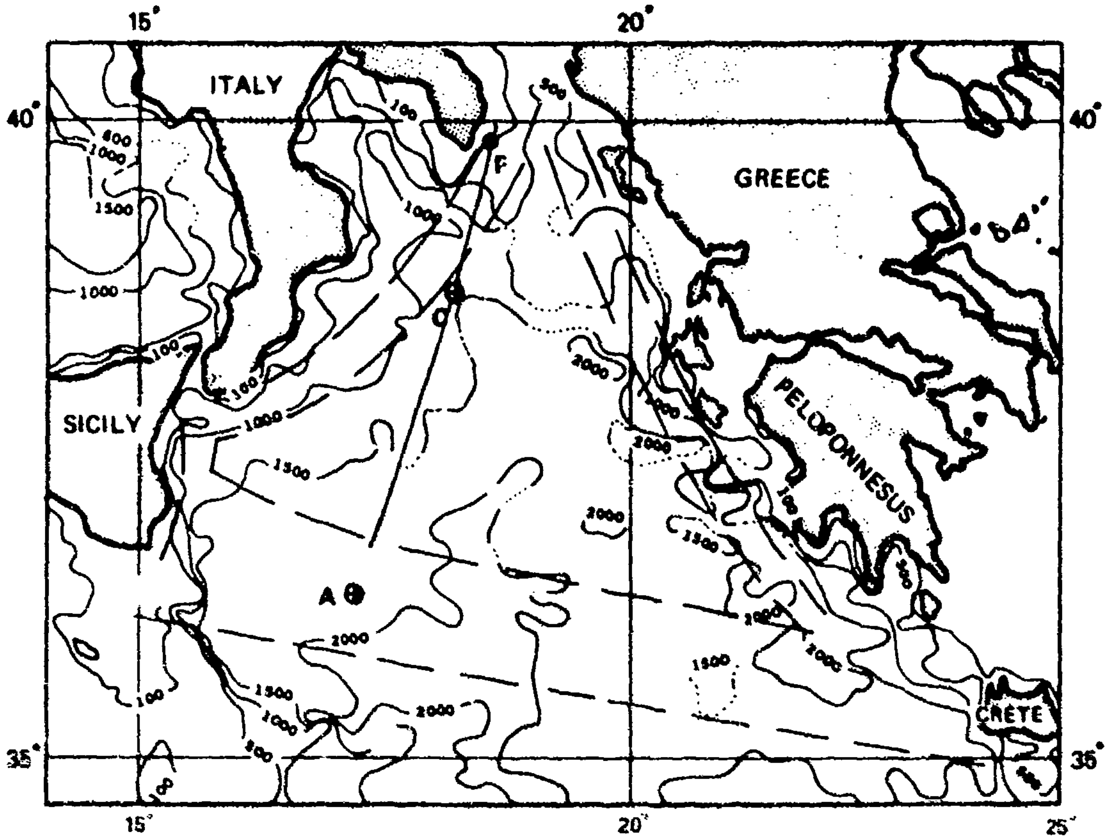
(U) Small changes in the shipping distribution are made to insure that the computed values of ambient noise are not overly sensitive to such changes. The magnitudes of the changes are compared to the expected uncertainties computed for the Project IOMEDEX situation to show the essential stability of the result.

The Experiment

(C) Three ambient-noise buoys (ANB) deployed at station C (Fig. 1) provided continuous ambient-noise data for five days simultaneously at hydrophone depths of 135, 615, 1115, 2375, and 2650 meters. A sound-speed profile for the area is shown in Fig. 2. A 125-Hz projector was towed at a depth of 152 meters along the track toward and away from station C shown in Fig. 1, between 1000Z and 2000Z on 13 November 1971. This track provides transmission loss toward the principal shipping lane, where most of the noise is expected to originate. On 14 November 1971 an extensive survey by four aircraft provided the best shipping information during IOMEDEX. Thus 14 November was chosen for the test of the ambient-noise model. The accuracy of the acoustic data used in this model test is: ±1.0 dB, ±2 minutes, and ±0.2 n.mi. Further details of the experiment and its results may be found in Refs. 3 and 4.

Results of the Model Test

(C) For this initial test azimuthal isotropy of the transmission-loss field was assumed. Transmission-loss data south of station C was used. Also, transmission loss at 50 Hz, the frequency of the model test, was taken to be the same as at 125 Hz [4]. Ambient noise levels were calculated each 10 minutes from 0600Z to 1800Z according to the method described in the first volume. In Fig. 3 these levels are compared with experimental values that were power-averaged for 2 minutes each 10 minutes through a 1/3-octave filter centered at 50 Hz.

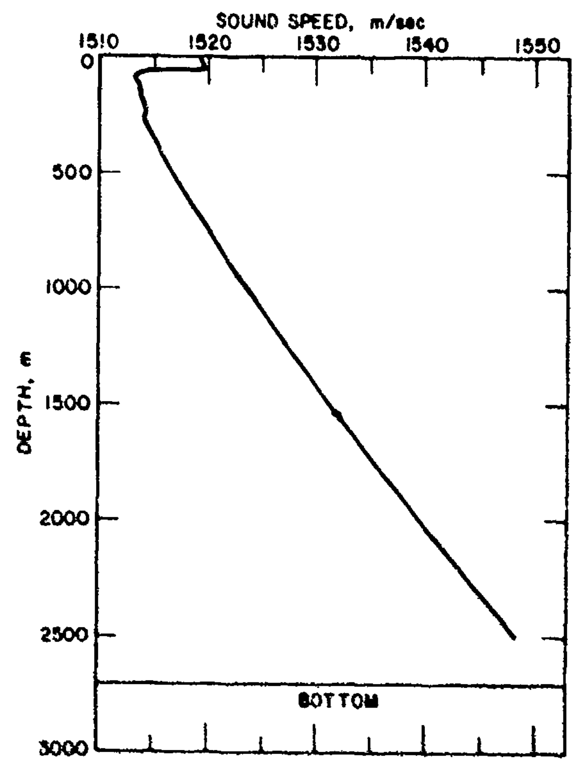


(C) Fig. 1—IOMEDEX locations: (A) 36°18′N, 17°12′E; (C) 38°38′N, 18°12′E; and (F) 39°50′N, 18°32′E. The solid line is the towing track for the projector to map the transmission-loss field, and the broken lines are shipping lanes.

Discussion

(U) The agreement of the time series is good at the upper three hydrophones. As shown by the scatter diagrams (Fig. 4) the differences are well grouped near median-zero. For the lower two hydrophones the calculated values are too low, arising from transmission losses which are too high for the following two reasons: Noise is radiated from surface ships at effective depths less than the 152-meter towing depth, so that noise radiated from surface ships is coupled more strongly to the lower hydrophones than the IOMEDEX data would suggest, and, since station C is near the edge of the Ionian Basin, propagation transmission from noise sources near the coast of Italy is better than propagation from noise sources south of station C at the same range.

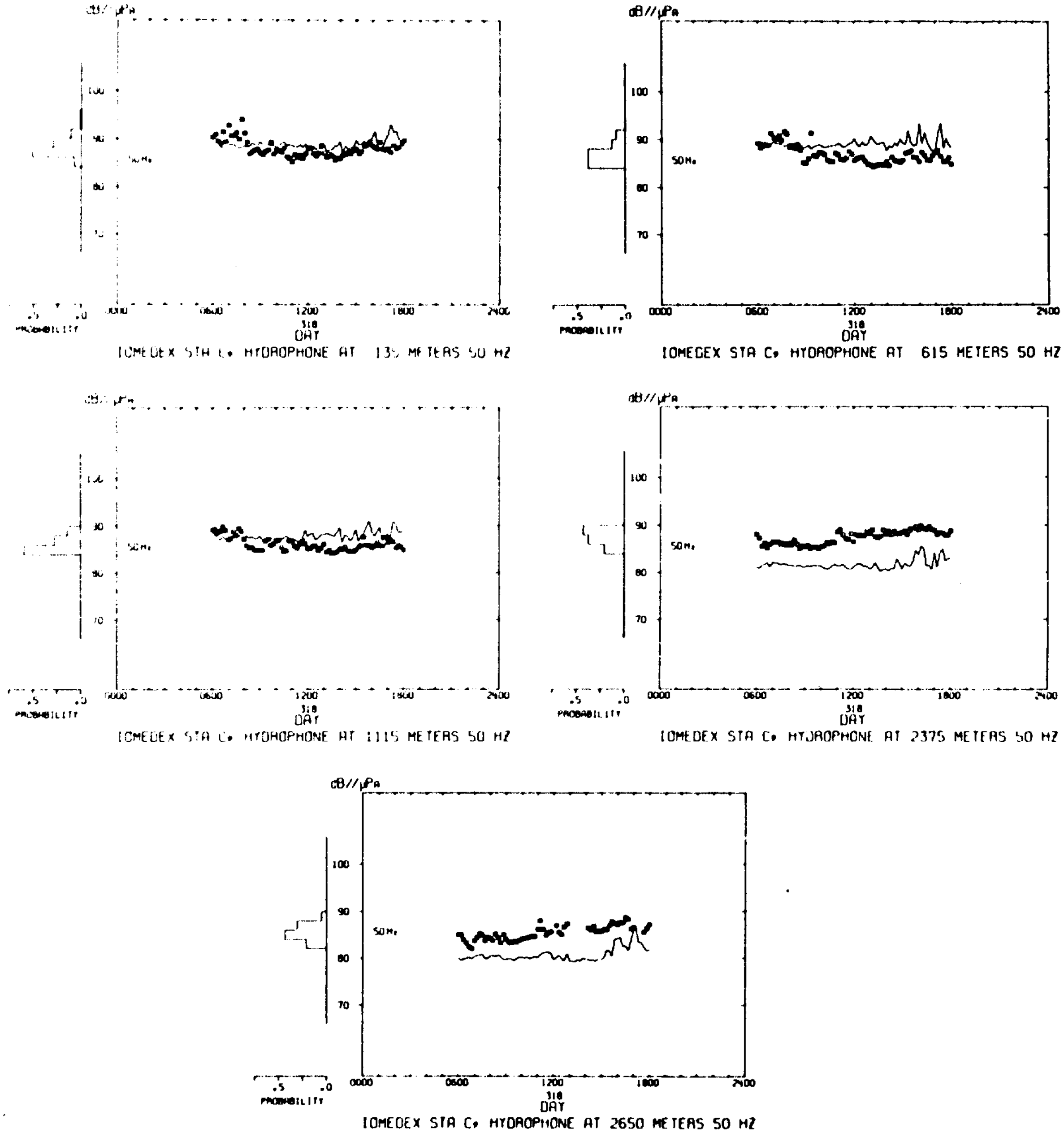
(C) The mean differences ($dB_{meas} - dB_{calc}$) for the five 73-point sets are shown in Table 1. As will be shown later, an error ϵ in a single value of ambient noise calculated from shipping and transmission-loss data, such as taken during IOMEDEX, may be expected to be about 1.2 dB. Thus, besides the two exceptions noted in the preceding paragraph, the ambient-noise model comes to within about 1 dB of realizing its ultimate expectancy. The assumption of azimuthal isotropy of transmission loss does not appear to be detrimental to the computation of noise in this case.



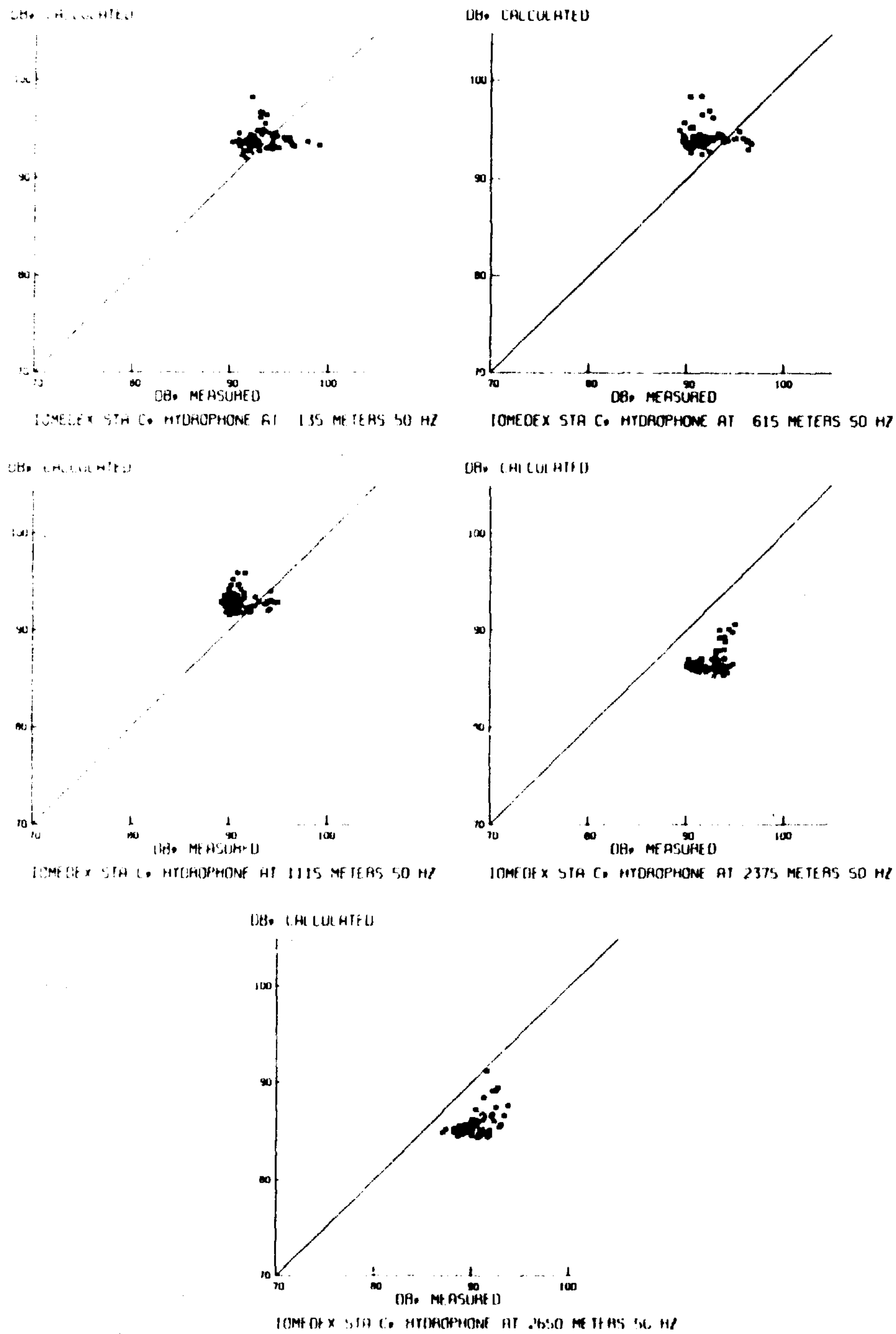
(C) Fig. 2—Sound-speed profile

(C) Table 1
Mean Difference
($dB_{meas} - dB_{calc}$)

Hydrophone Depth (m)	Difference (dB)
135	-0.8
615	-2.3
1115	-1.7
2375	+5.7
2650	+4.6



(C) Fig. 3—Ambient-noise time series, computed (line) and measured (squares), for five hydrophone depths. The histograms give the measured distributions in a 2-dB class interval.



(C) Fig. 4—Scatter diagrams for the data in Fig. 3

(C) It might be expected that a calculated ambient-noise time series would lack the variability of a measured one because of factors not taken into account in the calculation. Figures 3 and 4 indicate that this effect is not pronounced. The standard deviations σ are 1.4 to 1.7 dB for the experimental values, whereas $1.0 \leq \sigma \leq 1.2$ dB for the calculated values. Table 2 shows that, at 50 Hz, most of the noise at a given instant arises from only a few ships. Thus the fluctuations in the experimental time series of the upper two hydrophones shown in Fig. 3 are probably due either to propagation conditions different from those used in this computation or to anisotropic radiation from one or a few of the principal noise contributors; of the seven principal contributors which are responsible for 50% of the noise power, four were north of station C. The fluctuations near the end of the calculated time series on the other hand were due to a dead-reckoned transit of an aircraft carrier near the hydrophones; the track for this transit was probably in error owing to the carrier's maneuvering.

(C) Table 2
Contribution to the Computed Noise Power at 50 Hz

Noise Power (%)	No. of Ships	Computed Spectrum Level (dB//μPa)
25	1	83.4
50	7	85.9
75	31	87.8
100	211	89.0

CALCULATIONS OF AMBIENT NOISE LEVELS

The Model

(U) As was discussed and documented in the first volume, a set of digital computer programs has been written to model the ambient-noise field arising from ship traffic in time and space. The major inputs to these programs are shipping-survey and transmission-loss data. The programs take the input data and compute the ambient noise by

$$\mathbf{A}_j = 10 \log \sum_{i=1}^{N_s} 10^{(\mathbf{S}_i - \mathbf{T}_{ij})/10}, \tag{1}$$

where i refers to ships and j to time and where all quantities in dB are boldfaced.

(U) The unique features of this ambient noise model are as follows:

- A two-dimensional interpolation scheme for transmission loss uses a conformal mapping and avoids problems inherent in interpolating data by cubic splines.

- Ships are dead-reckoned using Mercator sailing [5] to produce a time history of ambient noise.
- The contribution of each ship is determined, then ranked so that the principal contributors to the ambient noise are quantitatively identified.
- The order of the calculation permits efficient multiple hydrophone and frequency computation using a single shiplist by using disk storage for the multidimensional transmission-loss field.
- Uncertainties (errors) in the calculation arising from multiple uncertainties in shipping and transmission loss are analyzed.

Ship Survey Data

(U) Station C (Fig. 1) is sufficiently far from the principal Mediterranean shipping lane that ships pass near the hydrophones infrequently. Thus it provides a location for taking acoustic measurements which is comparatively insensitive to shipping-survey observation errors. It is unlikely that every ship was spotted, and it is possible for the same ship to have been sighted again as a new ship by the same or different aircraft. Because of the limited capabilities of the sighting aircraft these data tend in addition to be incomplete. For example some of the ships' lengths and speeds and/or courses may be unknown. As seen in Table 2, however, underestimating the number of ships in a given area will not lead to a significant change in the ambient noise levels, provided that the "most important" ships have been sighted. Characteristic of this phenomenon is that a few big ships contribute most of the noise and the average ship contributes little.

(U) The programs for predicting ambient noise were designed to accommodate either detailed traffic data such as were obtained during IOMEDEX or archival data such as the average number of ships per 1° square. Detailed IOMEDEX survey data have been used to generate the time histories of noise as shown in Fig. 3, whereas archival data clearly are not suitable for that purpose. For IOMEDEX one to four aircraft surveyed the shipping. Estimates were made of the latitude, longitude, course, speed, time of sighting, type, name, and length of as many ships as possible within predesignated deep-water areas and straits in the Ionian Sea. For the ships whose speed or length was not found during the survey, the computer program determines the average speed and length of the ships for which estimates were made and assigns these average values to the ships having unknown lengths and speeds. If a ship's course is unknown, the program uses a uniform random number to generate a course. The procedure used in determining the speed and course from multiple sightings of the same ship is discussed in the first volume.

Ship Source Levels

(C) The ith ship's source level $S(f, L_i, s_i)$ is approximated as discussed by Ross and Alvarez [1] with the exception that the coefficient of the second term has been changed from 50 to 60 as suggested by supporting data [6,7]:

$$S(f, L_i, s_i) = N_0(f) + 60 \log\left(\frac{s_i}{15}\right) + 20 \log\left(\frac{L_i}{500}\right), \qquad (2)$$

where $N_0(f)$ is a frequency-dependent factor which was approximated by interpolating over the set of experimentally determined values given in Ref. 1; in this study $N_0(50)$ = 158 dB//μPa.

Error Analysis

(U) The computation error ε resulting from measurement errors in many input variables may be discussed independently of the computation itself. In this case a Monte Carlo method was applied to each of the independent variables for the appropriate number of ships, these errors being propagated through the calculation. The final error was derived from an average of 16 individual cases taken over an 8-hour time interval, following numerical convergence tests; details of the Monte Carlo program and error analysis are given in the first volume.

(C) A shipping density within an area typical of the Ionian Sea was chosen, along with characteristics typical of the ships found there. Observation errors were assigned to the IOMEDEX shipping survey (Table 3). At 50 Hz the Monte Carlo method gave a resulting noise level of 89.5 ± 1.2 dB//μPa for the hydrophone at 135 meters. The error $\underline{\varepsilon}$ = 1.2 dB is encouragingly small. To see if a significantly different shipping density

(U) Table 3
Input Data for Computing Errors $\underline{\varepsilon}$ in Noise

256 ships in 2.83×10^5 n.mi.^{2} ≙ shipping density of 1 ship per 1100 n.mi.
Course: ψ_i, uniformly distributed
$\sigma_\psi = 5°$
Speed: s_i, normally distributed about 15 knots
σ_s = 3 kt
Length: L_i, normally distributed about 400 ft
σ_L = 50 ft
Source level: S_i, according to Eq. (2), with normal fluctuations
σ_S = 4 dB
Transmission loss: $1/r_i$, with normal fluctuations
σ_T = 5 dB
Position: Uniformly distributed, $15 \leq r_i \leq 300$ n.mi.
σ_r = 2 n.mi.
Sighting time: All at $t = 0$ with normal fluctuations
σ_t = 1 min

would give rise to a different value of $\underline{\epsilon}$, another case was run: 128 ships inside a 1000-n.mi. radius. This case corresponds more closely to shipping in the Atlantic Ocean and yielded a 50-Hz noise level of 82.2 ± 2.0 dB//μPa. This error is still tolerable, but it must be emphasized that the uncertainties σ assumed in Table 3 require a good knowledge of the shipping.

(U) To test the sensitivity of the error $\underline{\epsilon}$ to specific input uncertainties, $\underline{\epsilon}$ was computed for a number of sets of input variables having uncertainties other than that set shown in Table 3. In Table 4 are shown the computational results of finding $\underline{\epsilon}$ when all input data except for the varied parameter are "standard" (as given by Table 3). Shown in the columns at the right are the results $\underline{\epsilon}$ from given varied parameters with other parameters held fixed at their "standard" values.

(U) Table 4
Variability of the Error $\underline{\epsilon}$ With a Parameter
("Standard" Noise Spectrum Level = 69.5 ± 1.2 dB//μPa)

Parameter	"Standard" Value	Varied Values	Error $\underline{\epsilon}$ for Varied Value of the Given Parameter and "Standard" Values of the Other Parameters (dB)
s	15 knots	10 knots	1.9
		20 knots	1.1
L	400 ft	100 ft	1.5
		200 ft	1.1
		800 ft	1.3
σ_s	3 knots	0 knots	1.0
		1.5 knots	1.2
		6 knots	1.7
σ_L	50 ft	25 ft	1.2
		100 ft	1.2
σ_ψ	5°	10°	1.1
		20°	1.3
σ_S	4 dB	2 dB	1.0
		8 dB	2.2
σ_T	5 dB	2.5 dB	0.8
		10 dB	2.5

(U) The effects of both better and poorer shipping-survey information than that taken during IOMEDEX may be seen in the table. From the fourth column it is apparent that there is a residual error of about 1 dB (for 256 ships in 2.83×10^5 n.mi.^{2}) in the ambient noise one might try to compute. On the other hand, even if relatively large errors are inherent in the shipping survey, computed values of average ambient noise should be within 2.5 dB of the true omnidirectional measured average value. The dominant influence of σ_S and σ_T overshadows other trends in this sensitivity test.

(U) The Monte Carlo result of 89.5 ± 1.2 dB//μPa may be compared with the mean experimental value for the 135-meter hydrophone during the 12-hour test interval of 88.1 ± 1.7 dB//μPa and the mean computed value for that period: 88.9 ± 1.0 dB//μPa. These three values agree quite closely, suggesting that the Monte Carlo method can be used to compute errors $\underline{\epsilon}$.

DISCUSSION

Use of the Model

(U) In the first volume the following assumptions underlying the computational method were discussed and qualified:

- Ambient noise for $20 \leq f \leq 120$ Hz is due primarily to shipping, and a single expression, Eq. (2), may be used to describe the radiated noise in this frequency band from all ships.
- The positions, speeds, and lengths of all ships in a given acoustic province can be adequately determined by survey.
- For computing 1/3-octave, omnidirectional ambient noise, the transmission-loss field about a receiver can be adequately determined by measurement.

Station C (Fig. 1) is sufficiently removed from the high-density shipping lanes, and is not on the basin's edge, so that the noise power level defined by Eq. (1) is averaged over many ships. Otherwise the preceding assumptions would not be justified.

(U) The rigorous application of Eq. (1) to a specific case is laborious; if an average ambient noise level is desired, in lieu of a time series, a statistical method of computation may be preferable. Such a computer program was found to give good results in this case of high shipping density.

Conclusions of the Model Test

(C) The purpose of the test was to evaluate the basic concepts of the method of computing ambient noise used at FNWC. The following conclusions have been shown, subject to the preceding assumptions:

- In areas of high shipping density the method of computing ambient noise from known shipping and transmission-loss data is valid.

- Errors in such a calculation depend on the many individual observational errors and amount to an expected error of about 1.2 dB in this test. This error increases with a decrease in shipping density.

- The transmission-loss field may be assumed to be azimuthally isotropic, except when the acoustic energy from noise sources interacts strongly with the bottom.

- Since expected errors are almost as large as the noise fluctuations, a Monte Carlo method of forecasting noise, easy to implement and yielding compact results, is as reliable as the more laborious method used by FNWC.

Recommendations

(C) The following extensions of the model should be considered:

- The model could be expanded to give reasonable predictions for frequencies other than 50 Hz. Also the model could be extended to handle line, planar, and volume sources of sound. In particular one could provide for the surface noise generated by winds and deep-ocean noise generated by currents, biological life, and geophysical events both discrete and continuous.

- The model can be used to predict features of ambient noise such as horizontal (azimuthal) directionality in lieu of undertaking costly measurement programs using TASS for example. Since, whenever hydrophones must be placed near shipping lanes such as in the Ionian Sea, the horizontal directionality of noise is so strongly dependent on the location of the TASS vessel with respect to the dense sources of shipping, noise forecasting offers a cost-effective means. However, as discussed in the first volume, ambient noise in a narrow beam and in a narrow bandwidth cannot be reliably predicted because of large errors in both radiated noise levels and transmission loss over a small number of sources.

- Because the water depth for the data reported by Ross and Alvarez [1] was only 19 meters, source levels are biased to the low side for frequencies below about 100 Hz [8]. Furthermore ship characteristics have changed somewhat, and a new class of merchant ships – supertankers – has emerged. Therefore additional radiated noise measurements are needed to provide improved source-level expressions.

- The source level, Eq. (2), can be extended to take into account ship type (cruiser, tugboat, etc.) and other pertinent ship parameters. A directory of characteristics of known ships, by name or class, could be developed to augment the information gathered by sightings. Theoretical models predicting the amount of noise expected from a ship having certain visible characteristics could be developed and compared with experimental measurements to improve our understanding of expressions such as Eq. (2).

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REFERENCES

1. D. Ross and F.F. Alvarez, "Radiated Underwater Noise of Surface Ships" (U), *U.S. Navy Journal of Underwater Acoustics*, 14, 331 (1964) (Confidential).
2. M.T. Dow, J.W. Emling, and V.O. Knudsen, "Survey of Underwater Sound Report No. 4: Sounds from Surface Ships," NDRC Div. 6 — Sec. 6.1, 1945.
3. S.W. Marshall and J.I. Bowen, "NRL IOMEDEX Summary Report," 20 Jan. 1972 (Confidential).
4. S.W. Marshall, "Ambient Noise and Signal-to-Noise Profiles in IOMEDEX" (U), NRL Memorandum Report 2638, June 1973 (Confidential).
5. N. Bowditch, *American Practical Navigator*, U.S. Navy Hydrographic Office, H.O. Pub. 9, U.S. Government Office, Washington, 1962, pp. 227-229.
6. "The Acoustic Fields of Ships of Various Kinds as Determined on the Mark 2 Acoustic Range at Wolf Trap," NOL Report 700, 1943.
7. "An Analysis of Mk 2 Acoustic Data from Narragansett Bay," NOL Report 809, 1943.
8. E.L. Sander, E.J. Moses, and R.L. Jennette, "Spectra of Radiated Surface Ship Noise at Low Frequency (U)," p. 97 in *29th Navy Symposium on Underwater Acoustics, Proceedings*, Vol. II, 1972 (Confidential).

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Unavailable	Baker, C. L., et al.	FACT MODEL. VOLUME II	Office of Naval Research	741201	ADA078539	U
ARL-TR-74-53	Anderson, A. L.	CHURCH ANCHOR EXPLOSIVE SOURCE (SUS) PROPAGATION MEASUREMENTS (U)	University of Texas, Applied Research Laboratories	741201	ADC002497; ND	U
MCR106	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 1 (U)	Maury Center for Ocean Science	741201	NS; ND	U
MCR107	Cherkis, N. Z., et al.	THE NEAT 2 EXPERIMENT VOL 2 - APPENDICES (U)	Maury Center for Ocean Science	741201	NS; ND	U
Unavailable	Mahler, J., et al.	INTERIM SHIPPING DISTRIBUTION	Tetra, Tech, BB&N, & PSI	741217	ND	U
75-9M7-VERAY-R1	Jones, C. H.	LRAPP VERTICAL ARRAY- PHASE IV	Westinghouse Electric Corp.	750113	ADA008427; ND	U
AESD-TN-75-01	Spofford, C. W.	ACOUSTIC AREA ASSESSMENT	Office of Naval Research	750201	ADA090109; ND	U